



**science
for the 21st
Century**

ATOMIC ION AND NEUTRON TRAPPING

will include research in atomic, ion and neutron trapping

Atoms and the fundamental units that they are made of — electrons, neutrons, and protons — typically zip around the universe at speeds that make them extremely difficult to study. For centuries the best that science could do was to show the effects these bits of matter had on certain materials.

In recent years, however, researchers have slowed atoms to a relative crawl by capturing them in optical and magnetic traps. This ability to trap large numbers of atoms allows researchers to conduct fundamental physics experiments with greater precision than previously possible. Atom trapping holds the promise for developing sophisticated tools for use in basic nuclear physics research, cold atomic physics and ultrasensitive detection for nonproliferation applications. Because the atomic trapping process is extremely selective and sensitive, it can make isotopic ratio measurements in samples as small as 10,000 atoms. This makes it an important tool for nuclear treaty verification and nonproliferation.

The history of atomic trapping at Los Alamos is relatively short, but significant. In 1997, researchers developed an atom trap that held up to six million radioactive atoms, 100 times as many as any previous effort. The magneto-optical trapping technology uses lasers to trap and cool radioactive rubidium-82 atoms from room temperature down to less than one-millionth of a degree above absolute zero. The process uses six laser beams to trap the atoms as a glowing, millimeter-sized cloud in the center of a chamber. Researchers count the number of atoms in the trap by measuring the amount of fluorescent light emitted by the cloud. The large numbers of trapped atoms and the relatively long time that they are held — up to 50 seconds — permitted much more precise measurements than before.

Antiproton trapping research at the Laboratory involves longstanding collaborations with scientists around the world. Before the 1996 shutdown of the Low Energy Antiproton Ring at CERN, Los Alamos scientists helped confine 1 million antiprotons in a trap for more than an hour. This project set the stage for the ATHENA (AnTiHydrogEN Apparatus) Experiment now under way at CERN which hopes to produce anti-hydrogen atoms at low energies, capture the atoms in a magnetic trap and compare the energy levels of antihydrogen to those of hydrogen.

In 1999 Los Alamos researchers were part of a collaboration that successfully confined neutrons in a three-dimensional magnetic trap to determine how long it takes them to decay. Using the reactor at the Center for Neutron Research in Gaithersburg, Md., part of the National Institute of Standards and Technology, neutrons were directed down the beamline into a neutron trap filled with helium chilled to minus 460 degrees Fahrenheit. A fraction of the billions of neutrons created by the reactor beam were confined in the long, narrow trap, which held the neutrons in the supercold liquid helium until they decayed approximately 12 minutes later.

In the 21st Century, particle and atomic trapping experiments will continue to provide scientists with more accurate measurements of particle lifetimes and improvements in the understanding of the weak force, which controls radioactive decay. Weak force is one the four forces that order the universe. The others are gravity, electromagnetism and the strong force. Cosmologists eventually will use the data from trapping experiments to refine models of the early formation of the universe.

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